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ABSTRACT

The World Wide Web is evolving from a collection of texts linked by hypertext and hypermedia toward services that operate interactively with the information user, and which offer results through use of a broad spectrum of tools. This paper presents a collection of interactive WWW services. The services are classified on the basis of the client software required to access them. The evolution of WWW services is shown with examples. In the future, more services will probably produce multimedia results based on information located on several distributed servers, in a close interaction with the user. This paper provides a brief description of the evolution of the WWW, describes and classifies advanced applications that are available on the Web, and discusses how the WWW might and should develop further. The selection of interactive sites is discussed. Items representative of the whole collection are listed by category and have a brief description in addition to their uniform resource locators (URLs). Categories include: meta search engines; HTML checkers; work and text; science and engineering; atlases and maps; games; and other collections of interactive WWW services. (Contains 18 references.) (Author/SWC)

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Highly interactive WWW services: a new type of information sources

ED 411 857

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Abstract: *The World Wide Web is evolving from a collection of texts linked by hypertext and hypermedia towards services that operate interactively with the information user, and which offer results through use of a broad spectrum of tools. This is demonstrated with the help of existing WWW services: a collection of interactive WWW services has been assembled and is made available through http://www.vub.ac.be/BIBLIO/InteractiveServices.html. The services can be classified on the basis of the client software required to access them. The evolution of the services is shown with the help of examples. In the future more services will probably produce (multimedia) results based on information located on several (distributed) servers, in a close interaction with the user.*

Keywords: Internet, World Wide Web, WWW, interactive services, active components, online access information

1. Introduction

Services on the Internet have evolved from online-accessible and CD-ROM equivalents of printed texts towards WWW hypertext and WWW hypermedia versions. Recently more reader interaction has become possible but, as a recent issue of *Nature* says (Ref 5), 'at present, Web documents are fairly static objects. You can look at them, download them and perhaps convert raw data into graphs by clicking on various plot options. But with most browsers that is about all. Indeed, the Web remains very similar to traditional publishing, with most users simply looking at information put there by others.' However, more and more that can be done on a computer will also be done on the WWW. Beyond static use lies the future of the Web: interaction.

In what follows we call the user's computer 'the client computer', or 'the client' for short; the computer that is called and on which a service resides is 'the server computer', or 'the server' for short. In fact, nothing has changed or has been added to this basic framework: at present, even the most advanced procedures for which the Internet is used still rely on the same basic principle of a user working on a client computer to obtain information from a remote server computer.

The procedures that are in now use have become more complicated on the one hand and more transparent for the general user on the other. A person who wants to get a quick taste of the WWW will have the impression that it is all very simple and easy. This impression of simplicity is wrong in a way: for instance, a question submitted to a search engine will almost always give some reply. The obtained result might even 'look good'. But a more experienced user will get 'better' results by using more adequate search engines and by formulating the request in a better way, adapted to the search engine(s). There exists a striking duality: the threshold to 'enter' the WWW has became smaller whilst becoming an expert user of the WWW is now much more difficult. We experienced this duality while we wrote this paper: subjects that are taken for granted turn out to be difficult to describe or define. But reflecting about these subjects is highly interesting. The impression of simplicity is also wrong for another reason. An inexperienced user might not be able to set up and maintain the client computer reliably: to do that, the user needs more experience. Such an effort means gaining more knowledge and spending more time. Most end-users are completely lost when something goes wrong with any technically advanced device, simply because of the high threshold. Another factor that increases this threshold concerns the variability or unreliability of URLs. All URLs mentioned in this paper were valid on 31 August 1996: no warranty can be given that they are still valid on a later date.

Let us try to define the subject of this paper in a simple way. With the help of the recent and advanced applications on the WWW we:

- sketch the evolution of the WWW;
- describe and classify advanced applications that are available on the WWW;
- discuss how the WWW might and should develop further.

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2. A first look at the evolution of WWW services

After the period when only electronic mail, FTP and telnet were used, the need for structuring and organising the available information existed. Gopher, veronica and other such 'animals' came and went, to evolve towards the World Wide Web (WWW or Web). HTML, the *lingua franca* of the WWW, was created. Many frequent users of the WWW do not even know that HTML stands for HyperText Markup Language and that the magic word 'hypertext' is the core of many actions on the WWW. A user, when simply clicking on a so-called hyperlinked word or item somewhere on the client's computer screen (the contents were transferred from a server computer), invokes a new process of transfer of information from some (possibly other) server computer back to the client computer. The user knows that a marked (often called highlighted) word or term is somehow linked to other information. It is the WWW client (browser) software that reads the HTML code, that presents the interpreted code in a readable form on the screen and that translates user requests (such as the clicking on a hyperlink) to commands that are sent to the server computer.

The most recent development on the WWW concerns active components which aim at improving the ability of users to interact with WWW servers. An active component is transferred from the server to the client computer. The component executes on the client computer. The information is (often continuously) prepared and presented on the user's computer by the WWW client. The component disappears again after finishing the task. Pioneer of the active components was Sun's HotJava client,which accepts so-called Java applets. Support for Java has been integrated into other client programs: Netscape Navigator and more recently also Microsoft's Internet Explorer. The Internet Explorer also supports ActiveX active components written in Visual Basic. NCompass has developed an extension for Netscape to enable it to work with ActiveX components (*http://www.ncompasslabs.com/products/Products_Main.htm*). Digital proposed Oblets, which are supported by Digital's own DeckScape, WebCard and WebScape WWW clients. Oblets are distributed active components written in Obliq, which is an object-oriented scripting language for distributed computing in a heterogeneous environment (Ref 3). Lucent Technologies, a spin-off from AT&T Corporation, brought Inferno, which was developed by members of the Bell Laboratories Computing Sciences Research Center (Ref 2). Inferno is a network operating system and programming environment. Very often comparisons are drawn between Java and Inferno. Such a comparison is only partly justified because Java is a programming language while Inferno is a full operating system which contains the language component Limbo. Bell Labs provides a comparison of Inferno and Java online (Ref 1).

Table 1 indicates which WWW client software allows use of Java and ActiveX components. The table reflects the status of the available software on 31 August 1996: the situation can change rapidly. Client software which is not mentioned in the table does not accept active components. A client that is not enabled for active components may (or may not) display an indication that an active component is present in an HTML page. The information in the table is compiled from texts provided online by Microsoft (Ref 10), Netscape (Ref 12) and Sun (Ref 14).

An extensive description of Java and HotJava is made available online by Sun (Ref 9). There is also a Usenet newsgroup about Java: *news://comp.lang.java* (very much oriented towards Java developers). Interesting overviews of the HTML 3.2 specification by Microsoft (Ref 7), including specific Internet Explorer HTML tags for ActiveX components, and the official Document Type Definition by the World Wide Web Consortium (Ref 18) can also be accessed online. A more extensive introduction to the subject of interactive use of the WWW has been written by Dawes & Tregobov (Ref 7). To summarise the development of the WWW up to the advent of active components, one should distinguish between plain or straight texts and hypertexts, between the use of one medium and multimedia documents, and between a low degree of user interactivity and a high degree of interactivity (where user input determines the further development of the content of the document). This is illustrated in Figure 1 and in Table 2.

Table 1: Which WWW client software allows use of Java and ActiveX components.

Operating system	WWW client software	Java capabilities	ActiveX capabilities
Intel-based			
Windows 95	Netscape 3.0	built-in	plug-in needed
	Internet Explorer 3.0	built-in	built-in
	HotJava 1.0 preBeta1	built-in	none
Windows NT 4.0	Netscape 3.0	built-in	none
	Internet Explorer 3.0	built-in	built-in
	HotJava 1.0 preBeta1	built-in	none
Apple Macintosh			
Macintosh 68K	Netscape 3.0		none
Macintosh Power PC	Netscape 3.0		none
Unix			
DEC Alpha OSF/1	Netscape 3.0	built-in	none
HP-UX	Netscape 3.0	built-in	none
IBM AIX	Netscape 3.0	built-in	none
Silicon Graphics IRIX	Netscape 3.0	built-in	none
Sun SPARC Solaris	Netscape 3.0	built-in	none
	HotJava 1.0 preBeta1	built-in	none
Sun SPARC SunOS	Netscape 3.0	built-in	none
BSDI Unix	Netscape 3.0	built-in	none
SCO Unix	Netscape 3.0	built-in	none
Caldera Unix	Netscape 3.0	built-in	none
Sony MIPS-based Unix	Netscape 3.0	built-in	none
NEC MIPS-based Unix	Netscape 3.0	built-in	none

Table 2

Document structure	Number of media	Degree of interactivity	Example
straight	single	low	plain text file, e.g. through FTP
		high	messaging, e.g. through electronic mail
	multiple	low	viewing a video clip
		high	video conferencing
hyperlinked	single	low	HTML file, text only
		high	HTML file with forms, active components ...
	multiple	low	HTML file with links to files in other media-formats
		high	HTML file with forms, active components, ... invoking files in other media formats

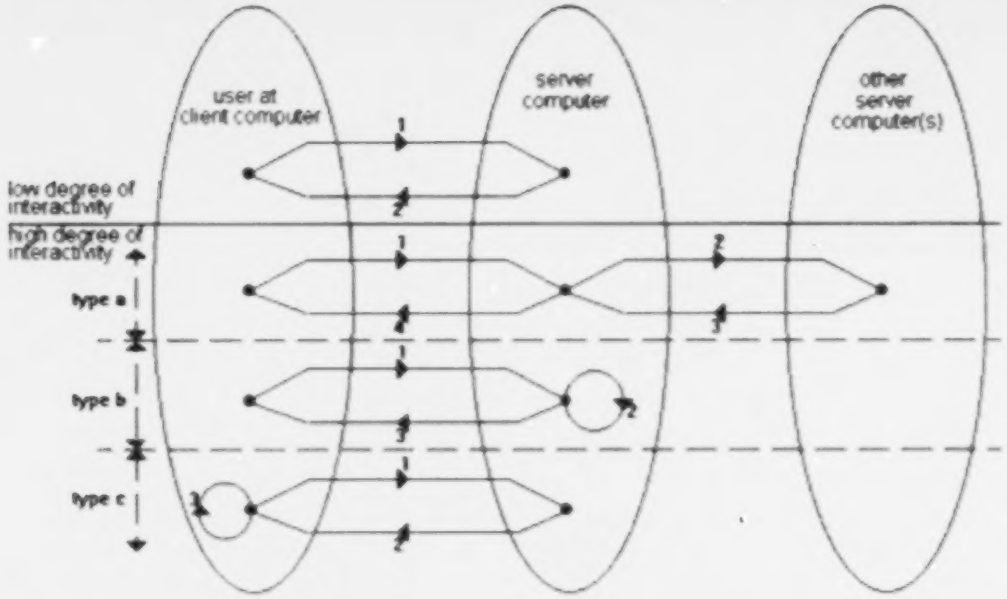

Figure 1: Types of interactive WWW services. The three types of services that have a high degree of interactivity (a, b and c) are selected. The flows of information are numbered, indicating the place in the sequence.

Udell (Ref 16) presents a view similar to ours on the evolution of the WWW up to the introduction of active components. Trupin (Ref 15) gives a how-to overview of Microsoft Internet Explorer version 3.0, Microsoft's extensions to HTML 3.2 and ActiveX.

3. Collection/selection strategy

The WWW pages discussed here are different from the majority of the material presently available on the WWW. The selected WWW services are preferably multimedia and most importantly have a high degree of interactivity, which is the subject of the paper (see Figure 2).

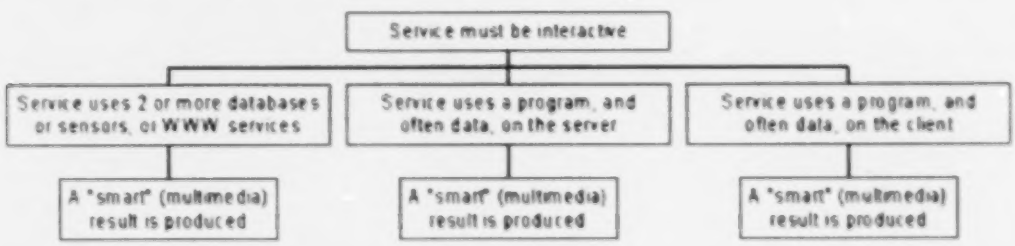
Service must be interactive
Service uses 2 or more databases or sensors, or WWW services
Service uses a program, and often data, on the server
Service uses a program, and often data, on the client
A "smart" (multimedia) result is produced
A "smart" (multimedia) result is produced
A "smart" (multimedia) result is produced

Figure 2: Scheme for the selection of a WWW service as an interactive service.

Another rather subjective way to describe the pages mentioned here is that they are 'smart' in the sense that input from the client is interpreted by the server (or active component on the client computer) and that the server sends back a response based on the client's needs or question.

We first had to look at what existed on the WWW. By a mental trial-and-error method we came to a simple set of selection criteria.

3.1. Types of low degree interactive WWW services that we **do not** select

(a) Services that allow retrieval (selection) of records (elements) from a database (for example bibliographic databases, telephone directories);

(b) Services that offer a momentary view (literally) through some instrument (camera or other sensor) (for

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example a view in a room with a digital camera or a view at the contents of a soft drink machine).

3.2. Types of highly interactive WWW services that we do select

(a) Services that address subsequent servers or tools, combine results, eliminate irrelevant or double information and thus offer a smart answer;

(b) Services that run a program on the server computer to produce a result (for example a service that computes the result of a definite integral or a service that computes an approximation of the Mandelbrot set and sends graphical results to the client);

(c) Services that run a program on the client computer to produce a result (the same examples of the previous point could be given here, except that the program codes are transferred from the server to the client and are executed on the client computer; this of course refers to active components).

WWW services offering combinations of the above types are possible. The three types of highly interactive WWW services are indicated in Figure 1.

Searching for these services is difficult as it is not possible to formulate a search and to submit it to Internet search engines. Alta Vista (*http://www.altavista.digital.com*) now includes a search field for the retrieval of Java applets, but not (yet) for other active components. The Yahoo catalogue (*http://www.yahoo.com*) contains fields to indicate for the presence of a Java application but these fields are not (yet) shown in the publicly accessible version (Ref 6).

For other highly interactive services one has to rely mainly on luck: other collections of interactive WWW services may contain services that satisfy our stringent criteria, one may incidentally discover a tool or somebody else may give a pointer.

4. The collection/selection of interactive WWW services

A collection of interactive WWW services that we found and selected is offered at: *http://www.vub.ac.be/BIBLIO/InteractiveServices.html*. The collection is still growing and it is clear that it will be never complete.

The following items from our collection are representative of the whole collection.

4.1. Meta search engines

A so-called meta search engine accepts a simple query formulation. The user has to specify one or several keywords: the server contacts several search engines and then offers an integrated result. This result contains a list of URLs from which duplicates have been eliminated. Two well-known WWW servers can be queried through the WWW:

- MetaCrawler Parallel Web Search Service (*http://metacrawler.cs.washington.edu:8080/*);
- SavvySearch (*http://www.cs.colostate.edu/~dreiling/smartform.html*).

4.2. HTML checkers

- WebTechs HTML Validation Service, which is more commonly known as the HALSoft validator (*http://www.webtechs.com/html-val-svc/*). This allows URLs of documents to be checked or a (small) part of an HTML document to be pasted in a form field. The document(s) can be checked against several document type definitions (DTDs) to be selected by the user;
- A Kinder, Gentler Validator (*http://ugweb.cs.ualberta.ca/~gerald/validate/*). This is a friendly, easy-to-use HTML validation service based on a real SGML parser. It is similar in function to the WebTechs validator but the returned error messages are easier to figure out.

4.3. Word and text

An overview of WWW servers about word and text was given by Pack (Ref 13). Some of the servers agree with the criteria outlined above.

- The Cyrano Server (*http://www.nando.net/toys/cyrano.html*) writes eloquent love letters and sends them by electronic mail;
- Internet Anagram Server (*http://lrdc5.lrdc.pitt.edu/awad-cgibin/anagram*): enter word(s) and it generates a list of anagrams;
- The Electric Postcard (*http://postcards.www.media.mit.edu/Postcards/*): choose a card, add your message and send it off. The recipient will be notified by electronic mail that a card can be claimed through a Pick-up Window;
- Crossword Solver (*http://www.eecg.toronto.edu/~bryn/HTML/Crosswords.html*): enter letters, with periods for unknown letters. All possible words using these letters are returned.
- Crossword Puzzle (Java applet) (*http://www.starwave.com/people/haynes/xword.html*): an interactive crossword puzzle. The puzzle is updated daily.

4.4. Science and engineering

The number of interactive WWW services related to science and engineering is by far the biggest. The following list is only a smaple from the vast offering available through the WWW, which is also the case for the other sections but especially for the science and engineering section.

- EqnViewer (Java applet) (*http://www.hookup.net/~cbazza/EqnViewer.html*). EqnViewer is a Java applet that allows equations to be added to a WWW page. Using a simple syntax to represent an equation one can easily insert any mathematical equation;
- Hydra-Mandelbrot/Julia fractal zoomer (*http://reality.sgi.com/employees/rck/hydra/*): zoom into the Mandelbrot or Julia fractal and graphically display the result with Hydra;
- Orientation of d-orbitals (Java applet) (*http://wwwchem.uwimona.edu.jm:1104/courses/CFTpt2.html*): Java applet that allows the orientation of the d-orbital lobes of the electrons in molecules (using wireframe representations of the orbitals that can be rotated by dragging them with the mouse) to be viewed with respect to the position of the surrounding ligands.
- Solar System Orbit Calculator (Java applet) (*http://www.humnet.ucla.edu/humnet/french/faculty/gans/java/SolarApplet.html*): dynamically shows the position of the inner (Mercury, Venus, Earth, Mars) or the outer (Jupiter, Saturn, Uranus, Neptune, Pluto) planets of the solar system. Also includes the four major moons of Jupiter, the Earth's moon, a couple of comets and a space ship that drops in from time to time (Figure 3).

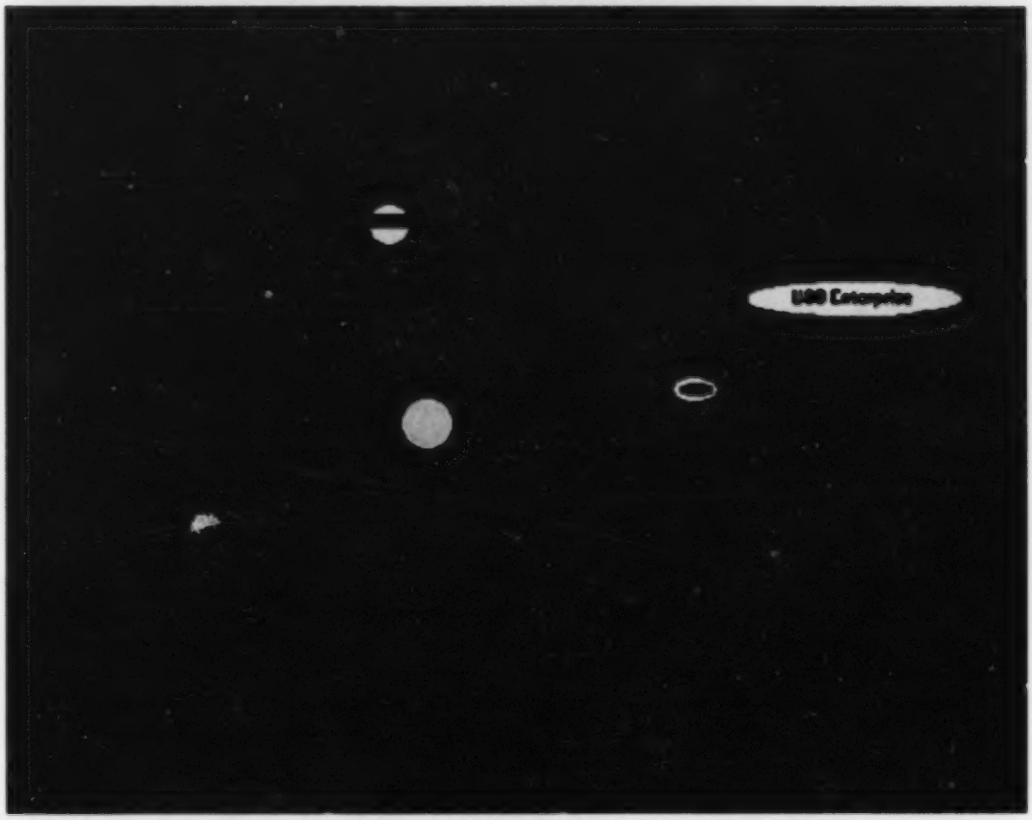

Figure 3: Screen capture of the Solar System Orbit Calculator.

- The Bradford (UK) automated remote robotic telescope (*http://www.telescope.org/rti/index.html*: the telescope and its use have already been discussed by Vanouplines & Nieuwenhuysen (Ref 17). This is our preferred example of a highly interactive WWW service. A user can set-up a complete job description for the telescope through a series of HTML forms. Help is provided in several ways by hyperlinks to classical help texts. Several tools for visualisation of the night sky are available. Once the job is submitted, the hardware and software built around the telescope monitor weather parameters, calculate the best observation time and make the astronomical observation only when all conditions are favourable. Jobs are scheduled on the basis of priorities which are mainly influenced by feedback from the user to the telescope operator (who can also raise or lower the priority level in very exceptional cases). The user is informed automatically by electronic mail upon completion of the job. The resulting picture or pictures can then be viewed through the WWW and downloaded to the user's computer where further image

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processing can be performed with software that is also available from the Bradford WWW site. Resulting images are offered as GIF files or as FITS files (the preferred format for astronomical images). The Bradford telescope is in fact the only telescope available through the WWW that fulfils our selection criteria; the following two telescopes are only added to show clearly the difference — vital parts of the procedure need human interaction and in fact they offer no more than a (sophisticated) view through a device;

- The University of Iowa Remote Telescope (*http://inferno.physics.uiowa.edu/*): this telescope allows submission of observation jobs. The job description is submitted with HTML forms. The content of a job is checked manually for its content. Once approved, the observation is made. The resulting images are stored as FITS files on an FTP server. One is informed about completion with an electronic mail message;
- The University of California at Santa Barbara Telescope (*http://www.deepspace.ucsb.edu/rot.htm*): jobs are prepared and submitted with HTML forms. The jobs for this Remotely Operated Telescope are also selected and launched by human interaction. After an electronic mail notification about the job completion, the user can collect the resulting FITS images on the institute's FTP server.
- Graphical Forecast Viewer (Java applet) (*http://www-md.fsl.noaa.gov/eft/internal/gfvDemo.html*): shows some prototypes of new products which could be produced by each US National Weather Office. Interactive maps displaying weather parameters (temperature, dew point, wind speed, etc.) are created automatically using the most recent data available. One can shift to another date or select another palette set-up by clicking with the mouse in control panels.
- Spectrum Analysis (Java applet) (*http://www.tmo.hp.com/tmo/appnotes/interactive/hp-am-fm.html*): a discussion and demonstration with Java applets of the theory of AM and FM modulation including time and frequency domain representations.

4.5. Atlases and maps

- Geodetic II — World Distance Calculator (Java applet) (*http://ourworld.compuserve.com/homepages/WGiel/geod2.htm*): Java applet to calculate the distance and direction between two points on the earth. Points can be specified by entering geographical coordinates or by pointing and clicking on a world map, or a US map;
- MapQuest Interactive Atlas (*http://www.mapquest.com*): interactive street guide, with access to maps anywhere in the continental US. Allows markers to be added to indicate points of interest. There are three versions: one using forms in combination with CGI scripts, a second using a Java applet and a third using an ActiveX component;
- Online Map Creation (*http://www.aquarius.geomar.de/omc/omc_intro.html*): create maps interactively by filling out an input form to specify map boundaries and projection, plot locations (cities but also user defined locations), geologic plate boundaries and other tectonic features;
- Canadian National Atlas Information Service (NAIS) (*http://ellesmere.ccm.emr.ca/naismap/naismap.html*): a geographic information system. Allows multiple National Atlas spatial data layers to be viewed and manipulated to compose a map of Canada (Figure 4).

4.6. Games

- Webcube (*http://info.gte.com/fun/cube/cube.html*): a version of the Rubik's Cube. It shows two views of the cube from opposite corners to see all six faces. To turn a face one can click on it or on 18 text links;
- WebMineSweeper (*http://genesis.tiac.net/mines.html*): a version of the minesweeper game. The game starts after selecting a minefield size. Shooting is done by clicking on one of the squares;
- Puzzle (*http://genesis.tiac.net/puzzle.html*): like a toy puzzle with sliding plastic squares. A square is moved by clicking on it so that it moves to the empty space.

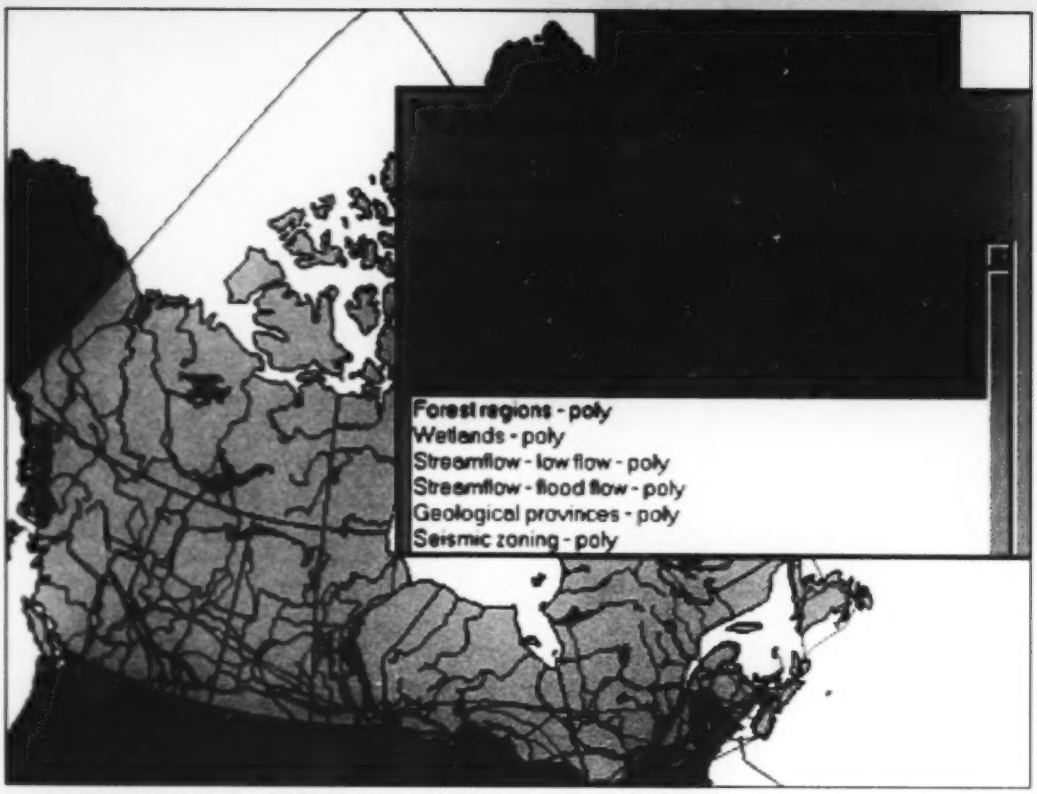
Forest regions - poly
Wetlands - poly
Streamflow - low flow - poly
Streamflow - flood flow - poly
Geological provinces - poly
Seismic zoning - poly

Figure 4: Example of a map obtained through the Canadian National Atlas Information Service.

4.7. Other collections of interactive WWW services

- MSN — Essentials (*http://www.msn.com/lookup/services.asp*): Microsoft offers a collection of pointers to helpful and handy WWW services. Only some of the MSN services collection pass the selection criteria presented earlier but the collection is noteworthy because of the nice form-based interfaces for each group of items. However, downloading the many forms for one group takes a long time when communication is slow;
- Gamelan — Earthweb's Java directory (*http://www.gamelan.com*): probably the most complete collection of Java components. Not that many items are highly interactive: most services transfer a simple program to the client computer, perform a simple task and display a text or graph on the client's screen. An example of a low-end Java applet is the Crossword puzzle; an example of a high-end Java applet is the Solar System Orbit Calculator (see above). The Gamelan collection also includes a list of ActiveX components;
- Applets from JavaSoft (Beta) (*http://java.sun.com/java.sun.com/applets/applets.html*): a collection of Java applets developed by Sun — a much smaller collection than Gamelan's but containing some interesting items.
- Microsoft's ActiveX Resources Area (*http://www.microsoft.com/activex/*): points users to lots of ActiveX components and to additional information on ActiveX;
- Mathematics Archives — Interactive WWW pages (*http://archives.math.utk.edu/interactive.html*): this list contains pointers to about 40 interactive WWW services that almost all fulfil the selection criteria presented here. Some of the services are small but useful tools, others are elaborate applications.
- Interactive WWW Maps and GIS (*http://www.sandia.gov/GIS/iwm.html*): a collection of WWW services with interactive maps or GIS.

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5. Classification of WWW services on the basis of the client software

5.1. Services for WWW clients, following HTML version 2, without extensions

Here we find servers that are in some way the most classical (not forgetting that the WWW emerged less than ten years ago and that most of the present users did not know about the WWW a two or three years ago). Nevertheless, these servers can bring a multimedia result by including hyperlinks to text, graphics, sound and/or video files.

5.2. Services for WWW clients, HTML+ capable

User input is often through fill-in fields or forms. The information is presented to the user in text or graphical format. Sometimes a multimedia result (with graphics, sound or video) is offered. Some servers offer a continuous update of information by using the server push/client pull method; in that case one gets updates of parts of the HTML page automatically.

5.3. Services for WWW clients that accept active components

The full power of active components is not yet well exploited. One could think of 'smart' active components that partially compute results on the client computer but collect additional information from other WWW servers, to offer the final result to the user. Such a procedure could lower traffic on the Internet: (intermediate) results are calculated on the client computer and no longer need to be transferred through the Internet. This is both to the advantage of the user, who gets the results quicker, and to the advantage of other users of the Internet.

5.4. Other WWW services

Apart from the three classes sketched above, there are client/server applications that can be attached to WWW client software. It turns out to be difficult to describe and to make a distinction between the classes described above and other classes of services:

- the distinction between them is vague;
- the classes, and therefore the boundaries between them, change rapidly.

Active components and the means used by WWW clients to handle them contribute to this fuzziness. Let us coin the term *active component handlers* (ACHs) for software supporting active component. The following applications can be distinguished.

- helper application:
  - functions mostly as a standalone program to display a certain type of information;
  - called by the WWW client after the complete document has been downloaded to the client computer;
  - developed to work with one platform, with no particular WWW client software in view.
- plug-in:
  - is not a standalone program;
  - can be called while the information is still downloading (this is streaming);
  - developed to work on one platform with one particular WWW client software.
- active component handler (ACH):
  - often built into WWW client software (e.g. the Java WWW client software supports Java active components, Microsoft's Internet Explorer has built-in support for ActiveX active components);
  - but can also be provided as a plug-in (e.g. the NCompass Netscape plug-in for ActiveX components and the just-in-time Java compilers from Symantec, Borland and Asymetrix);
- active component:
  - can be handled by an ACH and is executed as an application (in this case an active component can be considered as a plug-in);
  - can be a standalone program (e.g. the extreme example of the HotJava WWW client software which is written in the Java programming language);
  - one can think of active components that, once attached to WWW client software, allow that client software to support HTML extensions that did not exist at the time that the client software was compiled and distributed.

6. Discussion

First we observe that our collection/selection of highly interactive WWW services is small, at least in comparison with the total of more than 20 million WWW documents available now. This number of services will most probably grow dramatically in a near future.

The 'information provider' should no longer be one person, or belonging to a computer centre, or belonging to an information centre. Instead there should be a close cooperation between the two so that computer-oriented persons develop technically advanced applications that contain valuable information, provided for example by skilled information scientists. The 'information intermediary' in the library still analyses the patron's request, searches commercial databases and provides the patron with an answer. The information intermediary now also includes information obtained from or through the Internet and eventually points the patron to Internet sources, where the patron himself may scan for updated information. That includes that the information intermediary may have the task to explain the use of certain elements related to the Internet, while the patron may need further help, from the information intermediary or from the computer centre (or the Internet provider), to exploit the Internet.

As we said in the Introduction, the increasing demands of the user result in more complicated systems. The systems may seem to be simpler but still in fact have a high threshold for inexperienced users. Systems may look more transparent but they are not always easy to use. For example, a person in Europe wants to download a file residing on a server in the US. The developer of the WWW page provides information about mirror sites in Europe. The person obviously selects the 'closest' server but finds out that the download time is shorter when downloading the file from the US-based server. The person in Belgium does not realise that his Internet provider in fact 'enters' the Internet at a point in the US. The user may become completely confused when pointers in a WWW page link to servers all over the world. This is only one example. Also the distinction between a client, a server and the Internet may not be clear for the user. Even if that distinction is clear, the concept of software that is transferred from the server to the client computer for execution will be new. The transparency of the WWW may turn against the user in several cases. Documents on paper are, from that point of view, easier to use and more robust.

What will the future bring? Michael Lesk (Ref 8), discussing Vannevar Bush's landmark paper in which hypertext is predicted as early as 1945 (Ref 4) touches on problems of copyright, unfulfilled wishes about a one million electronic book library, the sudden death of the WWW (like CB radio) and less freely contributed work. But Lesk states about the WWW '[that] it looks like this going to work'.

Very likely in the future there will be a combined use of server computers with active participation from the client computer. When a user sends a request to a server, the server should not have all the information resident on its storage devices. Instead it could retrieve parts of information from one or more servers, combine the results and, if necessary, get additional information from other servers, and finally offer the combined information to the user. For instance, suppose that a person wants to travel from his home town, a typical small community (thus not present in a general geographic name base), to another small town in another country. The travel must be cheap and fast, making use of public transport facilities. The WWW server should first find out the location of the two towns; next the transportation means, the travel times and the connection hours; and finally the prizes for every transportation means for each part in all of the possible routes of the travel. Then comes another task: finding the 'best' solution, i.e. quickest and cheapest. Once that is found, the possibility of ordering subway, train and flight tickets could be offered. For such a complicated task we think that it might be economical to have an active component running on the user's computer. That application should consult the subsequent WWW servers and make the combinations locally on the user's computer. By doing so, the application could show the progress of the task (which will obviously take some time), thus reducing the subjective waiting time. Also, when one or more vital servers cannot be contacted the user can be informed about this and the advice could be given to try again later, while the intermediate results are stored on the user's computer. Later on, upon re-launching the request, the stored intermediate results can be loaded again without the necessity to perform the searches on distant servers all over again.

7. Conclusion

In this contribution we have shown that an evolution takes place from classical printed text, through hypertext, towards the use of highly interactive on the WWW. Over a relatively short period, several routes have been followed by WWW developers. Thus users of the WWW have seen more movement on and heard more sound from their computers. Texts are no longer what they were for centuries: there is a marked evolution from passive reading towards active and even interactive participation of the reader, who is becoming more and more the player.

WWW clients that support active components are only emerging. Impressive novelties are lurking behind the corner. It is not so difficult to predict that active components will substantially contribute to the evolution sketched here. It is much more difficult to predict how the evolution will continue, but we may be assured that there are many more impressive developments to come.

Is there life after active components? Our answer to this question is a wholehearted 'yes', but a warning is appropriate here. New developments are coming so rapidly one after the other that one may forget the ultimate target: the user. This is the single most important target: make the WWW easier, more complete and nicer, not just more impressive. The envelope may be nice but the message in it is the most important. Agreeing with the

final sentence of Lesk's (Ref 8) paper, we say: 'If we think of information as a sea, the job of the librarian in the future will no longer be to provide the water but to navigate the ship.' We could say that many WWW developers need to change their attitude from 'It may not be useful but it is at least beautiful', to 'It is not beautiful but it is useful!'.

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